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PROMOTING SCIENTIFIC AND TECHNOLOGICAL LITERACY AMONG POSTGRADUATE STUDENTS AT THE FACULTY OF EDUCATION UTM

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ABSTRACT

One important issue in the Science Education debate over the last century was how to prepare a more relevant science education of the 21st Century that emphasizes on promoting scientific literacy through a more meaningful science education program. In response to this call, a general science education elective course code named MPS1163 Epistemological, Social and Ethical Issues in Science and Technology was designed and implemented starting in Semester 2 Session 2009/2010. By the end of Semester 2 Session 2012/2013 the course has been running for 7 semesters and had invited 128 postgraduate students from 7 different programs, including a PhD program. A questionnaire was distributed to 26 course participants at the end of semester 2 Session 2012/2013. The objective of the questionnaire was to seek their personal assessment on their knowledge and understanding on the eleven course contents taken during the whole semester. The results indicated that there was a mean increment of between 40- 50% on their knowledge and understanding on the topics covered compared to their knowledge and understanding before taking the course. The second part of the questionnaire consisted of six items, using five point Likert Scale, seeking their suggestions for improving a more relevant science education through the elective course. The response was commendable. Implications of the study related to course contents and students opinions on the course contents and suggestions for the improvement of the course are discussed in this paper.

***Keywords**: scientific literacy, technological literacy, general education elective course, a more relevant science education.*

The term scientific literacy has multifaceted connotations. The word literacy comes from the Latin word "Litteratus" formed from the word "littera" which means "letter". It connotes "Man of Letters" or a "learned man". Through evolution the term literacy has changed its meaning to "ability to read, write and compute" which is also known as "basic literacy". Scientific Literacy is somewhat at a higher level than Basic Literacy. Some people are sceptical about its existence. However, in general, many educators believe that it can be operationally defined according to the context. Shen (1975) defined three categories of scientific literacy. Practical Scientific Literacy means having knowledge of science that is applied to solve daily life problems. As an example, a mother who chooses to breastfeed her child upon knowing that a mother's milk contains more protein and antibodies is said to possess Practical Scientific Literacy. Civic Scientific Literacy means having social responsibility on science related issues towards the welfare of society and its members. As an example, if one is committed to minimize the effect of pollution on the environment which can be the main source of many diseases in any way one can, then the person is said to have acquired Civic Scientific Literacy. Cultural Scientific Literacy is defined as having an appreciation on scientific discoveries as the greatest

achievement and endeavour of mankind. As an example, an architect reading an article on DNA is said to possess Cultural Scientific Literacy. Bybee (1997) defined three levels of scientific and technological literacy. Firstly, Functional Scientific and Technological Literacy, which refers to individuals who are able to respond adequately and appropriately to vocabulary associated with science and technology. Secondly, Conceptual and Procedural Scientific and Technological Literacy, which refers to individuals who can demonstrate an understanding of both the parts and the whole of science and technology as disciplines (Robert D A, 1983; Jenkins E.W, 1990). Thirdly, Multidimensional Scientific and Technological Literacy, which consists of understanding the essential conceptual structures of science and technology as well as the features that make that understanding more complete, for example, the history and nature of science and then relationship of disciplines to the whole of science and technology and to society (Lee Molly N.N, 1992).

Over the years with the intensive development of curriculum reforms taking place in the USA in the 1960s and 1980s, the concept of scientific literacy has broadened its meaning to mean the goal and objectives of science education. The theme for curriculum reform of the 1980s was "science for all" (Robert D.A, 1983; Gardner P. L, Penna C, 1985; Rutherford F. J and Ahlegren A, 1990). The two major curriculum reforms in science education taking place in the USA created a ripple effect on the development of science education in the West and worldwide. During the reform of the 1980s some of the projects developed include Educating Americans for the 21st century (National Science Foundation, USA, 1983), Science for Everybody (The Royal Society London, 1985), and Science for every student: Educating Canadians for Tomorrow's World (Science Council of Canada, 1984). Project 2061 is Science for All Americans, which focused mainly on scientific and technological literacy and educational standards (American Association for the Advancement of Science, 1985). The Malaysian Integrated Secondary School Science Curriculum (KBSM) was implemented in 1989 (Pusat Perkembangan Kurikulum Kementerian Pendidikan Malaysia, 1987; Lee, 1992; Tamby Subahan, 1987; Trowbridge L.C., 1996; Seth Sulaiman, 2000, 2001; Lee Molly N.N, 1989, 1992).

Basically, the development of individual education involves two types of academic enterprises. Firstly, the "special education", which relates to that part of education that looks at students' competence in some occupations. Secondly, the "general education", which first of all looks at their life as a responsible human being and citizen (Bybee, 1997). In preparing students for special education, it involves conceptual scientific knowledge which is termed as "constitutive knowledge", whereas for general education it involves knowledge which is related to daily life termed as "contextual knowledge" (Bingle&Gaskel, 1994; Fresham P.J, 1985). However, time has shown that so much effort has been emphasized on the development of the former in an obsession to produce scientists and technologists which is quite prevalent among higher institutions of learning. As a result, not enough effort is being done to develop general education involving contextual knowledge, which takes cognizance on the development of values and ethics. Responding to this need, an initial effort was undertaken by a group of science and mathematics educators at the Faculty of Education, UTM, to develop a general elective course at postgraduate level to pursue the goal and objectives of general education.

Course Descriptions and Contents

This is a three credit activity oriented course intended to enhance students' understanding on the brief history and philosophy of science, and on scientific method and processes. Furthermore, the course also emphasizes on developing students' awareness on social and ethical issues related to science and technology and the latter's strengths and limitations in the pursuit of human development. The course runs for 14 weeks at three hours per week. The contents encompass the brief history and philosophy of science and technology (S&T), which include epistemological and ethical issues, various definitions of science and technology, and their social implications; awareness on the adverse consequences of S&T and individual role to minimize their effects on the environment; relationships between science, technology and society; development of scientific skills, controversial issues in science and technology and decision making; scientific and technological literacy. The course assessment is based on individual written assignment (20%), project work in which students assigned in groups will conduct short study/or survey on a small group of selected community; seeking the latter's views on social and/or ethical issues related to science and technology (40%); and final examination (40%). Teaching and learning activities focus more on brainstorming, discussions of issues and group presentations of project work.

As we all know the course contents are quite diverse and wide-ranged in nature, particularly the social issues such as health and environment. Therefore the selection of course contents is very subjective. Much depends on the emphases that one would like to stress. In addition to social and ethical issues related to science, the topics on epistemological issues are also selected in an attempt to reduce teachers' prevailing misconceptions about science. This includes understanding of different types of scientific knowledge such as definition of hypothesis, theories, laws, scientific methods and scientific skills which are constitutive in nature. This topic is further justified by recent findings from research on epistemological beliefs and belief about learning which influence students' ability to learn (Gray et al., 2008; Sharifah M, Lewin K.L, 1993). Pulmones' (2010) study indicated that students with high sophistication of epistemological beliefs tend to view the knowledge that they learned to be relevant and applicable to their real life situation which is contextual in nature. Sim (2010) indicated that there is a significant relationship between epistemological beliefs and conceptual understanding of physics concepts (Pearson's $r=0.607$, $\alpha=0.01$) and between epistemological belief and learning attitudes (Pearson's $r=0.563$ $\alpha=0.01$) among the physics education undergraduates students at UTM. Therefore the majority of course participants whom are teachers need to be provided with good knowledge and understanding about science epistemology if we expect them to project a good image of science to students in schools.

METHOD

This is a survey attempting to investigate students' understanding on some selected general topics relating to the philosophical aspects of science (including Mathematics) and technology. The respondents were participants of an elective course code named MPS1163 Epistemological, Social and Ethical Issues in Science and Technology offered at the Faculty of Education Universiti Teknologi Malaysia.

The course started in Semester 2, Session 2009/10. As shown in Table 1, by the end of Semester 2, Session 2012/13, there were 128 participants from various postgraduate programs of Education enrolled in the course. At the end of Semester 2, Session 2012/13, a questionnaire was conducted to 26 course participants (2 participants were absent).

Table 1. Course Participants as respondents of the study

Program Semester	MPM	MPF	PPM	MPE	MPK	MPA	MPC	Total
2009/10/sem.2	9	7	1					17
2010/11/sem.1	13	2			2			17
2010/11/sem.2	11	1						12
2011/12/sem.1	22	9			5			36
2011/12/sem.2	6	1			5	2		14
2012/13/sem.1	1	1		1		1		4
2012/13/sem.2	19	1	2		3	2	1	28
Total								**128**

Legends:
MPM-MEd. (Maths.)
MPA-MEd. (Management and Administration) MPK-MEd. (Chemistry)
MPF-MEd. (Physics) PPM-PhD (Maths.)
MPC-MEd. (Curriculum and Learning) MPE-MEd. (Edu.Psychology)

Table 2 shows the breakdown of course participants in terms of ethnic groups and gender. The participants consisted of 1 Malay male student and 1 Indian male student. While the rest were 11 Malay female students, 7 female Chinese students and 7 female Indian students. As indicated from Table 1 they come from various programs as well as of different semesters of their study duration.

Table 2. Breakdown of course participants in terms of ethnic groups and gender

Ethnic Group/Gender	Malay	Chinese	Indian	Total
Male	1	0	1	2
Female	11	7	7	24
Total	12	7	7	26

The questionnaire consisted of two parts. The first part sought participants' personal assessment on their knowledge and understanding on the topics covered before and after completing the course. The second part of the questionnaire consisted of six items, using five point Likert Scale, seeking their suggestions for improving a more relevant science education through the elective course.

RESULTS ND DISCUSSION

Percentage increment of the participants' knowledge and understanding

The finding indicates that the mean percentage increment of the participants' knowledge and understanding on the topics covered through their self-assessment after completing the course is generally greater than 40% (Table 3). The highest increment of knowledge and understanding were on the topic Evolution of Science and Technology and its influence on the development of school curriculum (52.3%), and Ethics and values in Science and Technology (51.5%). Scientific methods and

processes and scientific skills registered the least mean increment, since as experienced teachers most of them are knowledgeable except with history and philosophy of science particularly topics related to values and ethics in science and technology and decision making.

Table 3. Mean increment on knowledge and understanding of the course contents (N=26)

No.	Topics	Mean Increment (%)
1	Diverse definitions of science and its interrelationships with technology.	46.4
2	Historical perspectives: Evolution of science and technology and its influence on the development of school curriculum.	52.3
3	Evolution of science and technology and its influence on the development of school curriculum	46.0
4	Types of scientific knowledge and its characteristics as an acquired knowledge in contrast with revealed knowledge.	48.0
5	Scientific method and processes. Scientific Skills.	42.5
6	Interrelationship between science, technology and society.	47.7
7	Model of Science, Technology and Society curriculum	47.8
8	Social issues related to S&T- Health, Environment and Technology.	47.1
9	Ethics and values in Science and Technology.	51.5
10	Controversial issues in Science and Technology	45.3
11	Scientific literacy and its operational definitions	48.4

Participants' opinions on the course for providing a more relevant science education.

Table 4 shows participants' opinions on the course in providing a more relevant science education for postgraduate education students. In the analysis the responses "strongly agree" and "agree" were grouped as "agree" and similarly for "strongly disagree" and "disagree" were grouped as "disagree".

The results indicate that 77.0% of the course participants agreed that the course should be opened to all postgraduate students, 19.2% neutral and 3.8% disagreed. For item ii 96.2% of the course participants agreed that the course had provided them with knowledge and awareness about the strengths and weaknesses of science and technology in the pursuit of human development, 3.8% remained neutral and none disagreed. Exactly the same proportion of agreement occurred for item iii, on the understanding of the differences between science and technology. For item iv which sought participants' opinion whether the course was about scientific and technological literacy for all, 84.6% of the participants agreed while 7.7% disagreed and 7.7% neutral about the statement. For item v which sought the participants' agreement on the inevitable marriage between science, technology and society, 88.5% of the course participants agreed, 11.5% neutral and none disagreed. Incidentally, exactly the same proportion of responses occurred on the course participants' agreement on the opinion that science, technology and society curriculum be introduced in schools.

Table 4. Participants' opinions on the course providing a more relevant science education (N=26).

Item	Item statement	Disagree (%)	Neutral (%)	Agree (%)
I	The course should be open as elective to all postgraduate programs	3.8% (1)	19.2% (5)	77.0% (20)
Ii	The course has provided me with knowledge and awareness about strengths and weaknesses of science and technology in the pursuit of human development.	0	3.8% (1)	96.2% (25)
Iii	The course provided me with much better understanding on the differences between science and technology	0	3.8% (1)	96.2% (25)
Iv	The course is about scientific and technological literacy for all	7.7% (2)	7.7% (2)	84.6% (22)
V	The course convinced me that the marriage between science, technology and society is inevitable for sustainable human living and development	0	11.5% (3)	88.5% (23)
Vi	Introduction of science, technology and society curriculum in schools.	0	11.5% (3)	88.5% (23)

Students' Open Responses

Only four respondents gave their suggestions as follows;-

Student 1 : "Need more discussion and activity in groups"

Student 2 :"This course should be upgraded by using some of science and technology materials.

Student 3 : "Expose more STS issues in the course so that students can relate with their daily life"

Student 4 : "All the students should present their work regarding their individual assignment so that the class have broader discussion and awareness about all the topic selected"

Students' Feedback from on-line evaluation of courses.

Senarai Komen PelajarSubjek MPS1163

(i). Overall, this class provides me adequate of knowledge and turn me into well skilled postgraduate.

(ii) An open-minded lecturer.

(iii) Pensyarahmemberikanpenyampaian yang baik dalam pengajaran beliau. tahniah!

(iv) Semua pelajar boleh menguasai subjek

(v) This course is very necessary for all postgraduates especially for science and engineering education in UTM

CONCLUSION

Generally, from the analysis of students' views and feedback, the course is relevant for them and efforts should be made to improve it. With the mean increment of almost an average of 50% of their knowledge and understanding on the course contents, it is imperative that teachers be exposed more on the contextual aspects of knowledge, be it during pre-service or in-service training. The program at the postgraduate level is one of such avenues. On the aspect of the course in providing a more relevant science education, generally more than 70% of the respondents agreed with the six item statements of relevance. The consensus was further corroborated by the students' open responses and students' on-line evaluation. Finally, undoubtedly in an effort to achieve Vision 2020 Malaysia requires more competent scientists and technologists for national development. However, at the same time we need to further enhance scientific and technological literacy by

developing good values and ethics among scientists, technologists, teachers and Malaysians in general, through a more relevant and meaningful science education.

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